# Michigan K-12 Science Standards
# Summary and Background on the Science Standards Development Process

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BACKGROUND

A New Vision for Science Education

Michigan's current K-12 Science Standards were written to provide guidance for K-12 science education as described by the Michigan Merit Curriculum (MMC, 2006). Based on national standards, assessment frameworks, and recommendations of the early 2000s, the Michigan K-7 Grade Level Content Expectations (GLCE) and High school Content Expectations (HSCE) represent ambitious expectations for Michigan students in the areas of Life, Physical, and Earth Science. Since the writing of the GLCE and HSCE, a growing body of research has provided significant insights on how students learn science, the need for a scientifically literate citizenry, a moral imperative to prepare all students for success beyond high school, and the power of standards that provide focus, coherence, and rigor in defining what students should know and be able to do.
In 2011, the National Research Council (NRC) released "A Framework for K-12 Science Education," which proposes a bold new vision for science education and served as a foundation for the development of new science standards (NRC Framework, 2012). As stated in the introduction to the Report Brief:

*Science, engineering, and technology permeate every aspect of modern life. Some knowledge of science and engineering is required to understand and participate in many major public policy issues of today, as well as to make informed everyday decisions, such as selecting among alternate medical treatments or determining whether to buy an energy-efficient furnace.*
*By the end of the 12th grade, students should have sufficient knowledge of science and engineering to engage in public discussions on science-related issues, to be critical consumers of scientific information related to their everyday lives, and to be able to continue to learn about science throughout their lives. They should recognize that our current scientific understanding of the world is the result of hundreds of years of creative human endeavor. And these are goals for all of the nation's students, not just those who pursue higher education or careers in science, engineering, or technology.*

The Framework provides a sound, evidence-based foundation for standards by drawing on current scientific research – including research on the ways students learn science effectively – and identifies the science all K-12 students should know.
The Council of State Science Supervisors (CSSS) produced a Science Framework Fact Sheet that provides a one-page overview of the NRC Framework.

The Next Generation Science Standards (NGSS) were developed to bring the vision of the NRC Framework to life in science classrooms. As described in the Introduction to NGSS, the standards represent significant advances in defining what ***all*** students should know and be able to do in science.

*Advances in the Next Generation Science Standards:*

- *Every NGSS standard has **three dimensions**: **disciplinary core ideas** (content), **scientific and engineering practices**, and **cross-cutting concepts**. Currently, most state and district standards express these dimensions as separate entities, leading to their separation in both instruction and assessment. The integration of rigorous content and application reflects how science and engineering is practiced in the real world.*

- ***Scientific and Engineering Practices** and **Crosscutting Concepts** are designed to be **taught in context** – not in a vacuum. The NGSS **encourage integration** with multiple core concepts throughout each year.*

- *Science concepts build coherently across K-12. The emphasis of the NGSS is a **focused and coherent progression** of knowledge from grade band to grade band, allowing for a dynamic process of building knowledge throughout a student's entire K-12 scientific education.*

- *The NGSS focus on a **smaller set of Disciplinary Core Ideas (DCI)** that students should know by the time they graduate from high school, **focus**ing on deeper understanding and application of content.*

- ***Science and engineering are integrated into science education** by raising engineering design to the same level as scientific inquiry in science classroom instruction at all levels, and by emphasizing the core ideas of engineering design and technology applications.*

- *The NGSS content is focused on **preparing students for college and careers**. The NGSS are aligned, by grade level and cognitive demand with the English Language Arts and Mathematics Common Core State Standards. This allows an opportunity both for science to be a part of a child's comprehensive education as well as ensuring an aligned sequence of learning in all content areas. The three sets of standards overlap and are reinforcing in meaningful and substantive ways.*

The NGSS call for students to build deep, applied understanding of disciplinary core ideas and science and engineering practices. They emphasize three-dimensional learning so that students develop the inquiry-

based problem solving, decision-making, critical thinking, and innovation skills they need to succeed in today's world of work. An additional perspective on the importance of the vision of the Framework and the NGSS is provided in this STEM Teaching Tool developed by the University of Washington Institute for Science and Math Education, "Next Generation Science Standards: What's different, and do they matter? "

## The Standards Development and Review Process

Upon release of the first draft of the NRC Framework in 2010, states began to plan for the development of common science standards. Michigan joined twenty-five other Lead State Partners to provide leadership to the NGSS development team.

Lead State Partners made commitments to:

- *Give serious consideration to adopting the resulting NGSS as presented.*
- *Identify a State Science Lead to attend meetings with writers to provide direction and work toward agreement on issues around the standards, adoption, and implementation.*
- *Participate in Multi-State Action Committee meetings (Committee of the Chief State School Officers) to discuss issues regarding adoption and implementation of the new standards.*
- *Publicly announce the state is part of the effort to draft new science standards and make transparent the state's process for outreach/receiving feedback during the process.*
- *Form a broad-based committee that considers issues regarding adoption and provides input and reactions to drafts of the standards.*
- *Publicly identify timeline for adopting science standards.*
- *Utilize the collective experiences of the states to develop implementation and transition plans while the standards are being developed that can be used as models for all states.*

Working together, teams of writers and reviewers from the Lead States as well as from stakeholder organizations produced a range of resources to support the standards, including the following:

- Standards Introduction – Executive Summary provides an overview of the standards, the development process, and the range of additional resources available to support interpretation and implementation.
- "How to Read the NGSS" describes NGSS architecture, components, and coding. A Michigan Specific version of this document will be created as a component of MSS guidance.

- "Next Generation Science Standards Topic Arrangement" – The NGSS PEs (the assessable statements that define what students should know and be able to do) are organized under a limited number of Topics for each grade level or grade band. These have been rearranged for the Michigan K-12 Science Standards document for SBE adoption.
- Supplemental NGSS resources released in 2013.
- As described in the NGSS Introduction, the NGSS are supported by information organized in thirteen appendices and a Glossary of Terms. Each appendix is developed to provide additional support for understanding an aspect of the NGSS. All NGSS resources are available at the official NGSS site.
- Additional NGSS implementation resources are being developed by teams from states that have already adopted NGSS and others as a function of the NGSS Network.

As a partner in NGSS development and as a lead supporter of the professional learning support that will be necessary as teachers and leaders transition to the NGSS, NSTA has developed a wide range of professional learning and implementation support resources which are housed at the NGSS@NSTA Hub.

- An overview of the NGSS organized by Topic and by DCI
- An overview of the relationship among the practices of science, literacy, and mathematics

<u>Michigan's Participation in the Next Generation Science Standards Development and Review</u>

Michigan actively participated in the development of the NGSS as a Lead State Partner. Michigan team members provided input and leadership as members of the NGSS Writing team, the Michigan Internal Review Team for NGSS, and through "special focus area reviews" of the standards documents and ancillary materials.

Two Michigan professors served on the 41-member NGSS Writing Team (composed of members from the 26 lead states). Both were team leaders, and Michigan was the only state to have more than one team leader in the process.

- Melanie Cooper, Lappan-Phillips Professor of Science Education and Professor of Chemistry, Michigan State University
- Joseph Krajcik, Director, CREATE for STEM Institute and Professor, Science Education, Michigan State University; Chair of the Physical Science writing committee.

Writing team members wrote, reviewed feedback, met with State Leads, revised, and monitored NGSS development.

The Michigan NGSS Internal Review Committee provided meaningful and significant input into the development of the NGSS from September 2011 through the April 2013 release. The initial committee included 37 Michigan educators, but increased in size during the development process to include 66 Michigan educators ranging from elementary education, secondary education (6-12), post-secondary education, informal science educators, including representatives from the Michigan professional science organizations (MSTA/NSTA, MSELA, MMSCN), and MDE staff. Members were selected to provide expertise in all areas of the NGSS, and represented a cross-section of the state. Members reviewed three internal drafts (December 2, 2011; February 1, 2012; September 21, 2012) and two public drafts (May 18, 2012; January 4, 2013) of the NGSS throughout the development process – a total of five in all. The MI STEM Partnership in conjunction with the Michigan Math and Science Centers Network, hosted NGSS public review sessions during both public review windows. Michigan Science Teachers Association (MSTA) leadership hosted face-to-face meetings of the NGSS Internal Review Team and facilitated discussions with members. After each round of review, Achieve hosted feedback review sessions to discuss findings, and to get additional feedback from State Leads. A list of those Michigan educators who participated in these review efforts will be posted on the MDE Website.

In July and August 2012, Lead States responded to a number of specific questions regarding important decisions for the final NGSS format and content. In addition to providing feedback on internal and public drafts of the NGSS, Michigan NGSS Internal Review Team members served on committees that focused on development of the material in the NGSS appendices.

Three specific efforts were completed to provide "special focus area reviews" of the standards

- Andy Anderson, MSU, provided an early review on the Cross-Cutting Concepts (CCC) Matter and Energy. He outlined the need to strengthen this area and provided specific language used in NGSS Appendix G – Crosscutting Concepts
- In June 2012, a 6-member team of Michigan postsecondary educators met with counterparts from the other Lead States to review the NGSS and discuss College and Career Readiness. (Claudia Douglass, CMU; Janice Tomasik, CMU; Alex Azima, LCC; Bruce Farris, LCC; Sonja Siewert, Westshore CC; Ryan Sweeder, MSU, Susan Codere, MDE). A

related College and Career Ready message was presented at the Michigan NGSS Introduction, May 28, 2014.
- In April 2013, as the Internal Review Team prepared for the May 28, 2013 Introduction to the NGSS Conference at MSU, members developed resources to support NGSS implementation.

Michigan educators were offered two additional opportunities to review and comment on the NGSS after the final versions were posted.

- In April 2013, MDE hosted a public comment period (April 10 through May 8, 2013) with opportunities to participate in two online surveys – one regarding support for NGSS, the other relating to professional learning needs for NGSS implementation.
- On May 28, 2013, more than 800 educators and stakeholders participated in the Introduction to the Next Generation Science Standards Conference, sponsored by MSU CREATE for STEM Institute, MSU College of Education Office of K-12 Outreach, and the Michigan Department of Education. Participants were introduced to the standards and had the opportunity to provide feedback on their professional learning needs as they applied to NGSS implementation.

## STAKEHOLDER FEEDBACK ON THE STANDARDS

### Overview of Michigan Public Feedback on the Next Generation Science Standards

Michigan provided public feedback for two public drafts (May 18, 2012; January 4, 2013).

During the 1st public review period (May 2012), Michigan had the 5th highest number of visits to the NGSS website (8816 out of a total 176,032), and the 3rd highest average web visit duration (8:31 minutes) out of all 50 states. Michigan's general public feedback included 614 respondents who identified Michigan as their state of residence. (This number does not include the Michigan NGSS Internal Review Team Members or critical stakeholder responses.) This represents the highest number of survey respondents of those who identified a state of residence (5,491), and represents 11% of the total U.S. public feedback. Only about half of the respondents identified a state of residence, so it is reasonable to assume that Michigan's total representation was actually higher than these numbers suggest. This huge early response to NGSS is largely credited to the review sessions hosted at each of Michigan's 5 STEM hubs and 33 Math and Science Centers, and to the extensive outreach done by the Michigan Science Teachers Association through their Science Matters eblasts and regional reviews.

During the 2nd public review period (January 2013), Michigan had the 3rd highest number of visits to the NGSS website (12,654 out of a total 181,680), behind only CA and NY. Michigan's general public feedback included 416 respondents who identified Michigan as their state of residence. As in the May 2012 review, only about one half of all respondents identified a state of residence. The 416 Michigan responses represent 8.2% of the total responses from individuals who indicated their home state.

Michigan teachers, STEM partners, and other interested parties placed high importance on reviewing and responding to the NGSS drafts. Review session leaders provided feedback to Internal Review Team Members for inclusion in more formal discussions.

Michigan also collected public feedback on the final April 2013 NGSS, in support of adoption. Of 244 respondents, 92-98% agreed or strongly agreed with the vision and focus of the NGSS and support adoption and implementation (Coherent K-12 progression (94%); All students prepared (96%); Dimension integration, engagement (94%); Cross-disciplinary integration and application (95%)). Strong supporters stressed a need for professional development to guide transition, beginning with implementation

of the science and engineering practices in current instructional units or lessons; careful planning for continued transition over 3 to 5 years; sharing of resources (open source, online access to exemplars); and opportunities to develop formative (classroom) assessments and to build capacity for teachers to help to develop summative (including state-level) assessments. Others expressed support for NGSS but articulated concerns about being given the time for professional development; having access to the necessary resources to implement the practices as intended; the need for assessments that align with the models of good instruction and actually support good instruction; and the need for time to build capacity of teachers to teach the standards before high-stakes testing of the standards.

Michigan participated in NGSS review sessions and in NSTA Critical Stakeholder Reviews. Throughout the stages of NGSS development, MDE representatives worked with members of the review team and eventually with external stakeholder groups to plan for the supports that will be necessary to support science education in Michigan and the transition to NGSS. From May 2013 to April 2014, MDE developed a transition plan that has been shared with the State Board of Education in a series of presentations.

## Summary of Reviews of Next Generation Science Standards and Michigan's Science Standards

Following the publication of the Next Generation Science Standards, multiple individuals and organizations provided reviews and analyses of the standards, as well as of existing state standards, in order to better understand the considerations for implementation, and the potential impact this would have on student learning in science and/or societal values and outcomes (such as a science-literate workforce).

General opinion on NGSS, especially relative to existing state standards in science for many states was very positive, with several organizations issuing statements of support for adoption and implementation of NGSS. Links to the reviews, and an MDE summary of reviews, will be posted on the MDE web site.

A Content Comparison Analysis for the Next Generation Science Standards and Michigan Science Standards

Due to the variation in reviews and feedback, primarily from the Fordham Foundation report, MDE and the Wayne Regional Education Service Agency (Wayne RESA) contracted with SRI International's Center for Technology in Learning to conduct an external, independent content comparison review of the Michigan Science Standards (MSS) and the Next Generation Science Standards (NGSS). The report, *A Content Comparison Analysis of the Next Generation Science Standards and the Michigan Science Standards*, includes content comparison analyses of the NGSS and Michigan K-7 GLCE and High School Essential Expectations (HSCE-Essential), a description of the unique features of the NGSS, and recommendations and rationale for adopting the NGSS as Michigan's Science Standards.

The recommendations are summarized in this excerpt from the executive summary. *These results provide compelling evidence of the value added by the adoption of the NGSS to improve science education in Michigan. Recommendations from these findings include:*

- *Michigan should consider the adoption of the NGSS performance expectations, in order to improve science education for students in all grades.*
- *The NGSS Science and Engineering Practices and Crosscutting Concepts provide coherence across content areas and should be implemented to enhance current science education instruction for grades K-12.*
- *The NGSS performance expectations for the Disciplinary Core Ideas in Engineering, Technology and Application of Science contain new content that should be included in science instruction across all grades.*
- *The NGSS performance expectations provide explicit connections to Common Core Mathematics and English Language Arts Standards that should be integrated into science instruction.*
- *NGSS Professional Development Resources are available through participation in the NGSS Network and should be leveraged to support Michigan science teachers.*

This full report can be found on the MDE Web site. Note that the document refers to the Michigan Science Standards as the standards that are current as of this publication, which were adopted in 2006. The proposed Michigan Science Standards are derived from the Next Generation Science Standards, and so all recommendations should be applied to the proposed Michigan Science Standards.

TRANSITIONAL SUPPORTS

Support for Transition to New Michigan K-12 Science Standards

Those involved in the development and review of the NGSS realize that transitioning to full NGSS implementation as reflected in aligned curriculum, instruction, and assessment at local and state levels will be a multi-year process. It will require adjustments in all components of the system – from professional preparation for pre-service teachers to learning for teachers to curricula, instruction, and assessments to time allocated for science during the school day – with each aligning to the vision of the Framework.

> *HOW CAN THE VISION OF THE FRAMEWORK BE REALIZED?*
> *Students will make the greatest strides in learning science and engineering when all components of the system—from professional development for teachers to curricula and assessments to time allocated for these subjects during the school day—are aligned with the vision of the framework. Aligning the existing K-12 system with that vision will involve overcoming many challenges, including teachers' familiarity with new instructional practices and the time allocated to science. The full report identifies such challenges to help educators and policymakers begin to consider how to meet them. It also offers recommendations to guide standards developers and lays out a research agenda to inform updates of the framework and standards in the future.*
>
> Report Brief: A Framework for K-12 Science Education, 2011

As described in a recent article in Engaged Scholar by Lead Writer for NGSS Physical Science Standards, Joseph Krajcik, Director of MSU's CREATE for STEM Institute:

> *New Standards are Only the Beginning:*
> *New standards, however, are only part of the picture to bring about sustained change to our educational system. Along with the standards, teachers and school systems need new curriculum materials, assessments to monitor student progress, teacher professional development so that science teachers can learn new content and new teaching practices, and new resources— including equipment—for students to explore phenomena. Revision of how K-12 science teachers are prepared at the university level is also needed.*
> *The overall effort is indeed ambitious. Yet, this ambitious agenda brings many opportunities to revitalize our science classrooms to help all children learn science and to develop the conceptual tools to live in*

*an ever-changing global society. We only have to look at the trends in current educational, economic, and environmental statistics to foresee our children's future—which looks grim if we don't act to restructure our current science education system. With the release of NGSS we have new opportunities. Our science classrooms will change to prepare our children for the world they live in. Research shows that when curriculum materials incorporating science and engineering practices blended with core ideas are introduced in the classroom, even in the nation's poorest schools, students rapidly make measurable gains in scientific learning. We will need professional development to accomplish this; however, our teaching pool is ready, capable, and willing to move forward.*

*With the release of the Next Generation Science Standards in 2013, we have a once-in-a-generation opportunity to dramatically affect the teaching and learning of science and engineering, building a 21st century workforce with vital long-term economic and development outcomes.*

As referenced in the Michigan NGSS Lead State information, science education in Michigan is supported by a strong professional network of partners.

> *There are strong professional alliances in Michigan that assist with science education advancement statewide. The Michigan Science Teachers Association puts on one of the nation's largest annual conferences, and there are strong professional educator organizations in the following content areas, earth sciences, biology, chemistry, and physics, which result in strong professional development, communication, and educator resources. The Science Matters/Building a Presence network Michigan branch is one of the largest in the country with approximately 3,500 teachers representing over 60% of school buildings involved. These members receive a complete update on all national and state science education information, which again helps with communication and professional development within the state.*

In addition to MSTA and Science Matters, Michigan science teachers are supported by the Michigan Math and Science Centers Network, and the Michigan STEM Partnership, members of the Michigan Science Professional Learning Network (MI-SCI PLN), MSU's CREATE for STEM Institute, and STEM – support programs in other Michigan Institutions of Higher Education, as well as the Michigan Virtual University (MVU).

Planning for Transition

One way to identify the scale of the change to be made is to evaluate current practice in terms of the **conceptual shifts** called for by NGSS. For districts in which there is little focus on science instruction in the elementary grades, the NGSS represent a huge shift. For districts that have developed science instructional plans that reflect the research recommendations on which the current Michigan science standards and the NGSS are based, the shifts may appear to be less daunting.

The NGSS Adoption and Implementation Workbook developed by Achieve, Inc. and the U.S. Education Delivery Institute, provides questions for planning to make the transition to NGSS based on six conceptual shifts identified in the NGSS. These same areas of focus were identified by Michigan teachers as those in which additional support for transition would be welcome.

Conceptual Shifts

1. K–12 science education reflects the real-world interconnections in science.
2. All practices and crosscutting concepts are used to teach core ideas all year.
3. Science concepts build coherently across K–12.
4. The NGSS focus on deeper understanding and application of content.
5. Science and engineering are integrated in science education from kindergarten through grade 12.
6. Science standards coordinate with the CCSS in English language arts/ literacy and mathematics.

Another resource that will support teachers and science leaders in revising their instructional plans to better reflect the intent of the NGSS is Brian Reiser's 2013 analysis titled "What Professional Development Strategies are Needed for Successful Implementation of the Next Generation Science Standards?" Dr. Reiser summarizes the shifts that will need to take place in terms of teacher knowledge and practice and highlights areas that will need to be addressed in pre-service teacher preparation programs as well as in professional learning supports for current science teachers.

Summary of Shifts in Teacher Knowledge and Practice

Taken together, the shifts motivated by the Framework and NGSS are substantial. They reflect a systematic shift in how teachers need to think about how to motivate lessons and support students' sensemaking in

investigations. Yet we know that these approaches are feasible for teachers to develop, and are productive for student learning when they do so (NRC, 2007).

Several themes have emerged from this analysis that may pose challenges for many teachers:

- Lessons should be structured so that they work is driven by questions arising from phenomena, rather than topics sequentially pursued according to the traditional breakdown of lesson.
- The goal of investigations is to guide construction of explanatory models rather than simply testing hypotheses.
- Answers to science investigations are more than whether and how two variables are related, but need to help construct an explanatory account.
- Students should see what they are working on as answering explanatory questions rather than learning the next assigned topic.
- A large part of the teachers' role is to support the knowledge building aspects of practices, not just the procedural skills in doing experiments.
- Extensive class focus needs to be devoted to argumentation and reaching consensus about ideas, rather than having textbooks and teachers present ideas to students.

Teachers need to build a classroom culture that can support these practices, where students are motivated to figure out rather than learning what they are told, where they expect some responsibility for this work of figuring out rather than waiting for answers, and where they expect to work with and learn with their peers. It is clear from this analysis that curriculum materials and assessments that reflect NGSS-aligned approaches, by themselves will not be enough, unless teachers can support the students' science practices as targeted in NGSS-aligned curriculum materials and assessments. Yet, piecemeal changes and learning new isolated techniques will not be enough. This new vision represents substantial changes in how teachers engage in the practices of science teaching. Many teachers will need extensive support, not just in learning about NGSS, but in learning, trying out, and getting feedback on what it means to teach with this vision.